# Performance of different filters for determining temporal mass variations from GRACE in the Siberian permafrost region

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## Introduction

Permafrost in Siberia (Russia) is one of the challenging phenomena in the context of climate warming. GRACE can help to quantify the mass variation contributions, but GRACE monthly gravity solutions suffer from less accuracy at shorter wavelengths of the Earth's gravity field and from the correlation of the spherical harmonic coefficients. Therefore applying efficient filters for de-correlating Stokes coefficients is indispensable in the post-processing of GRACE solutions. In this poster, different isotropic and non-isotropic filters (e.g. the Gaussian filters with different radii, Fan-filter and DDK filters) are applied to the new release 05(a) of the monthly gravity field solutions from two analysis centres (i.e. GFZ and UT-CSR) to extract mass variations in Siberia.

## Data & Processing

- New release of GRACE gravity field solutions of **GFZ (RL05a)** (d/o 90) and **UT-CSR (RL05)** (d/o 60)
- Time span from **2003-01** to **2013-12**
- $C_{2,0}$ has been replaced for all solutions based on newly released SLR solutions *(Cheng et al. 2013)*
- **1D** isotropic **Gaussian** filter (350 km), **2D** non-isotropic **Fan-filter** and different **DDK** filters *(Kusche et al. 2009)*
- Estimation of secular trend and periodic contributions with 161-day, annual, 2.5- and 3.7-year periods

## GFZ RL05a

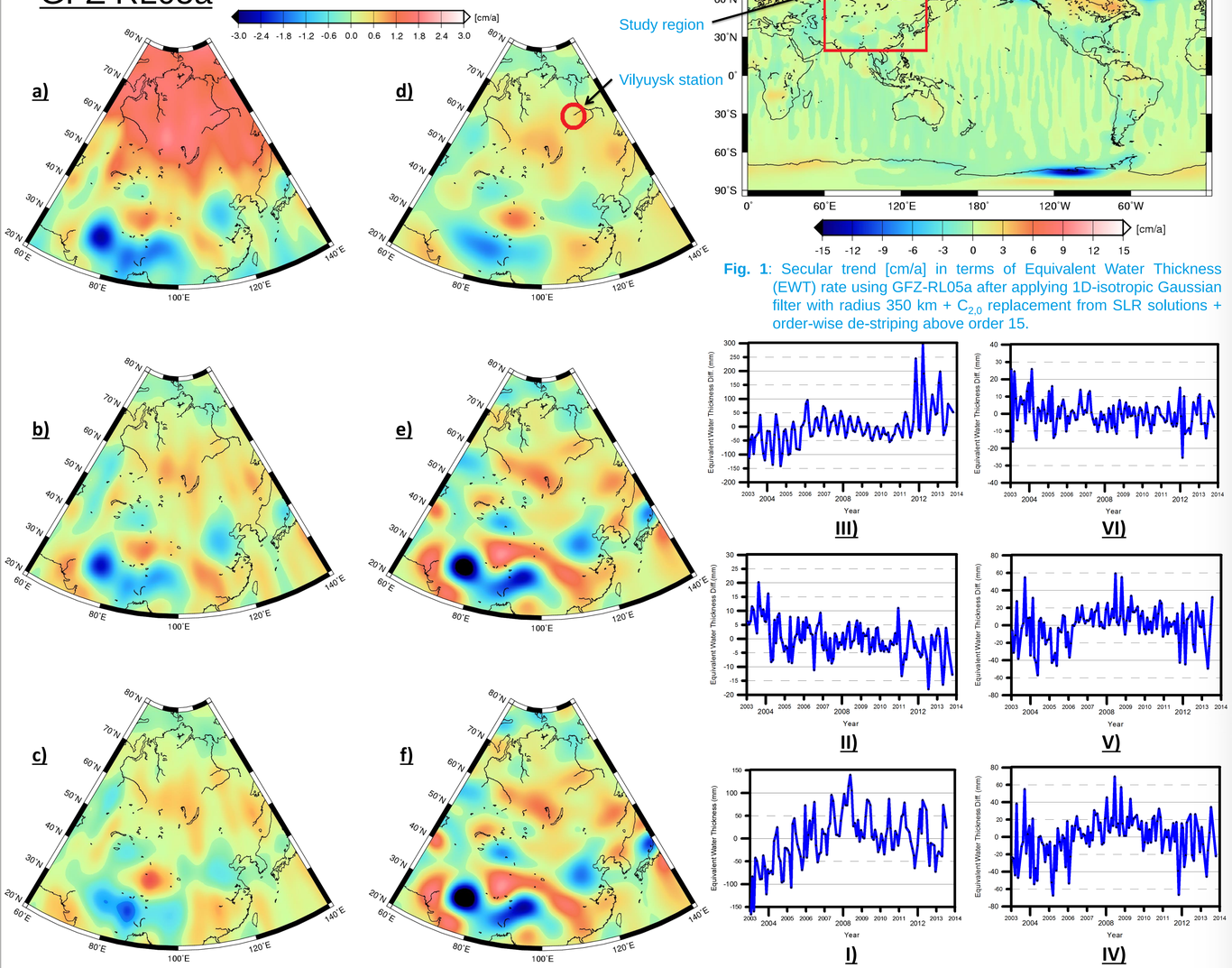


**Fig. 1**: Secular trend [cm/a] in terms of Equivalent Water Thickness (EWT) rate using GFZ-RL05a after applying 1D-isotropic Gaussian filter with radius 350 km + $C_{2,0}$ replacement from SLR solutions + order-wise de-striping above order 15.

**Fig. 2**: Secular trend [cm/a] of EWT rate in the Siberian permafrost using **GFZ-RL05a** after applying: **a) 1D-isotropic Gaussian filter** with radius 350 km **b) 1D-isotropic Gaussian filter** with radius 350 km + $C_{2,0}$ replacement from SLR solutions **c) as case (b)** + order-wise de-striping above order 15 **d) 2D non-isotropic Fan-filter** with radius 350 km + $C_{2,0}$ replacement by SLR solutions + order-wise de-striping above order 15 **e) DDK3 non-isotropic filter f) DDK4 non-isotropic filter** *(Kusche et al. 2009)*.




**Fig. 3**: Mass variation in mm of EWT in Vilyuysk station (central Siberia) based on GFZ-RL05a after applying: **I) Filtering as case (c) II) Difference** of cases (c) and (b) **III) Difference** of cases (c) and (a) **IV) Difference** of cases (c) and (f) **V) Difference** of cases (c) and (e) **VI) Difference** of cases (c) and (d).

## UT-CSR RL05

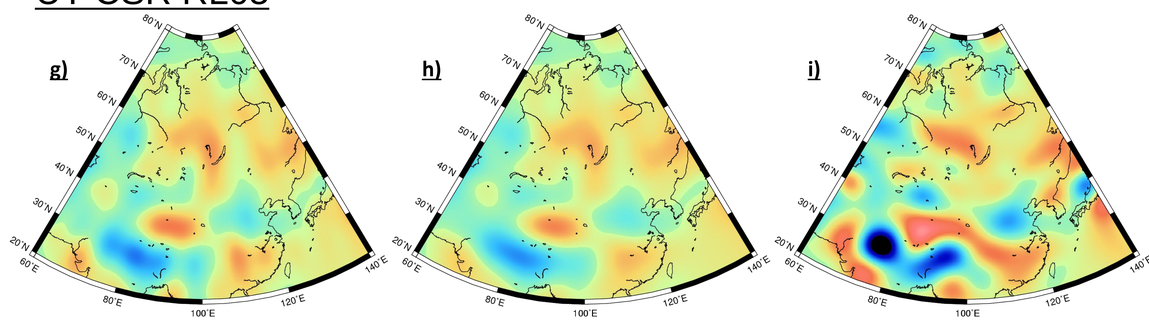


**Fig. 4**: Secular trend [cm/a] of EWT rate in the Siberian permafrost using **UT-CSR RL05** after applying: **g) 1D-isotropic Gaussian** filter with radius **350 km +** $C_{2,0}$ replacement from SLR solutions + order-wise de-striping above order 15 **h) 2D non-isotropic Fan-filter** with radius 350 km + $C_{2,0}$ replacement by SLR solutions + order-wise de-striping above order 15 **i) DDK3 non-isotropic filter.**

**Tab.1**: Statistical values of secular trend estimation for different filters using GFZ-RL05a at latitude range [20-80°], longitude range [60-140°].

| Filters / Stat. [cm/a] | Gaussian 350 km: only | Gaussian 350 km: + $C_{2,0}$ repl. from SLR | Gaussian 350 km: + $C_{2,0}$ repl. from SLR +de-striping above order 15 | Fan-filter 350 km + $C_{2,0}$ repl. from SLR + de-striping above order 15 | DDK3 + $C_{2,0}$ repl. from SLR | DDK4 + $C_{2,0}$ repl. from SLR |
|---|---|---|---|---|---|---|
| **Min.** | -2.7 | -2.5 | -1.9 | -1.6 | -3.9 | -4.5 |
| **Max.** | 1.9 | 1.2 | 1.5 | 1.2 | 2.0 | 2.1 |
| **RMS** | 0.87 | 0.44 | 0.41 | 0.37 | 0.65 | 0.68 |
| **Average** | 7.6 | 1.3 | 1.3 | 1.3 | 1.2 | 1.2 |

## Discussion

- $C_{2,0}$ has a significant impact on the mass variation estimation.
- Isotropic filters & non-isotropic filters show slightly different mass variation trends in the region of Siberia.
- 2D Fan-filter with radius 350 km after replacing $C_{2,0}$ from SLR seems to be the optimal filter for Siberia.
- GFZ and UT-CSR solutions provide similar result of mass variations in the Siberian permafrost region.
- The separation of mass variations should be improved by assimilation of lake surface extent and height variations from satellite altimetry and hyper-spectral satellite data with different temporal-spatial resolutions.
- Vey et al. (2012) attributed 30-60% of mass variations in the Siberian permafrost region to surface water storage changes. Thus, permafrost thawing can reach up to 0.6 cm/a of EWT rate.

Referecens

**1) Cheng, M.K. et al. (2013):** Deceleration in the Earth's oblateness, Journal of Geophysical Research, Vol. 118, p. 1-8, Doi:10.1002/jgrb.50058.

**2) Kusche, J. et al. (2009):** De-correlated GRACE time-variable gravity solutions by GFZ, and their validation using a hydrological modeling: Journal of Geodesy, Vol. 83. No. 10.

**3) Vey, S. et al. (2012):** Long-term water storage variations in the Siberian permafrost regions derived from various satellite data, GRACE Science Team Meeting, Potsdam, Germany.

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